

Shuttle Impact Assessment of Brominated Flame Retardants

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Discovery



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- ***Concern:*** Banned BFRs may cause a reformulation of products, possibly leading to undetectable failures
 - ***Objective:*** Assess the impact of BRF elimination/replacement on the Space Shuttle Program (SSP) applications

BACKGROUND

- United States Environmental Protection Agency (USEPA) issued a Final Rule on 6/13/06 concerning the use of Polybrominated Diphenyl Ethers (PBDEs). These include:
 - Tetra-BDE - Hepta-BDE
 - Penta-BDE - Octa-BDE
 - Hexa-BDE - Nona-BDE

** Deca-BDE is not included on the current EPA list*
- Significant New Use Rule (SNUR) under Section 5(a)(2) of the Toxic Substances Control Act (TSCA)
 - Requires manufacturers and importers to notify EPA prior to manufacturing or importing certain chemicals.

BACKGROUND (cont)

• *European Union Regulations*

Regulation	Content	Compliance Deadline	Affected BFR
WEEE Directive	Separation of BFR plastics from Electrical & Electronics (E & E) equipment prior to recovery /recycling.	December 2006	All BFRs for Electronics & Electrical usage.
RoHS	Ban of use in new Electrical & Electronics applications.	July 1, 2006	Penta-BDE, Octa-BDE, PBB
RoHS	Exempted from ban in E&E applications since Oct. 15, 2005		Deca-BDE
Directive/ Water Policy	Establishment of controls of emissions, discharges in the environment and water quality standards.	Not Applicable	Deca-BDE Octa-BDE
Directive/ Water Policy	Cessation of emissions in the environment.	2020	Penta-BDE
24th Amendment	Ban of use for all applications in the EU market	Aug 15, 2004	Penta-BDE Octa-BDE
4th Amendment	Ban from textile applications in the EU market	November 1984	PBB (no longer produced since 2000)

Note: All regulatory references obtained from the following website sponsored by the Bromine Science and Environmental Forum
http://www.bsef.com/regulation/eu_legislation/



APPLICATIONS FOR BROMINATED FLAME RETARDANTS (BFRS)

- BFRs are widely used in electronics manufacturing
- Additives to plastics, rubber, foam
- Provide stability and effectiveness in inhibiting or preventing combustion
- Easier and more cost effective recycling with plastics containing Polybrominated diphenyl ethers (PBDEs)



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BFRs IN COMMERCIAL APPLICATIONS

General material categories identified by Commercial Boeing that are known to contain BFRs:

- Adhesive Tapes/Glass Cloths
- Laminating Systems
- Potting Compounds
- Polyether-Urethane Foams
- Epoxy Fillers
- Insulation Sleeving/Tubing



SEVERAL BFRs USED BY COMMERCIAL AIRCRAFT ARE ALSO USED BY THE ORBITER

Materials identified in both commercial and space applications

- Potting Compound

(found on GSE, and completed testing on replacement)

- Polyurethane Foam

(Supplier has discontinued the use of BFRs)

- Polyolefin Tubing

(Major supplier has discontinued the use of BFRs)



GOALS OF SHUTTLE BFR SUB-TEAM

✓ **Determine need for evaluating replacements**

✓ **Perform Risk Assessment**

- What are the risks from reformulated BFR's to the Space Shuttle Program
- How is each element affected

✓ **Determine costs for identifying and evaluating replacements**

Figure 1. Chemical structures of (A) PBBs, (B) PBDEs, (C) HBCD, and (D) TBBPA.

IMPACTS FROM BFR FORMULATION CHANGES

- Vendors are changing the formulations of materials containing BFRs due to bans of penta-BDE, octa-BDE and now deca-BDE
- Users are not always notified of formulation changes
- Replacement materials may have to be identified
- Other families of flame retardants are being used as replacements
- Performance of the materials may be impacted
 - ♦ Flammability, Adhesion, Tensile Strength
- Requalification of newly formulated materials may be required

IDENTIFICATION OF BFRs IN SSP APPLICATIONS

Element	BFR Identification Status
ET (External Tank)	<ul style="list-style-type: none"> •No BFRs identified in Thermal Protection Systems (TPS). •Flame retardant in TPS is FR1138 (Ethyl Manufacturer). Stockpiled since 1995 due to material obsolescence. •Will utilize Ameribrom 522 in future flame retardant applications. •Both have CAS Number 3296-90-0.
Orbiter	<ul style="list-style-type: none"> •Penta -BDE identified in Epocast 87005, a self-extinguishable two part epoxy. Manufacturer is Furane Aerospace Products. <ul style="list-style-type: none"> •Epocast 1629 is the suitable non-PDBE replacement. •Deca-BDE identified in RNF 100 Tubing, a polyolefin based heat-shrinkable tubing. Manufacturer is Tyco Electronics. • The flammability rating for RNF 100 tubing has changed from an “A” or “B” rating to an “X” rating. A new MATCO identification number designated for tubing with “X” rating. <ul style="list-style-type: none"> •Resources are unavailable to qualify a replacement for RNF -100 tubing. <p>* Search not near completion</p>
SRB (Solid Rocket Booster)	<ul style="list-style-type: none"> •Thermal Curtains do not contain penta- BDE or octa-BDE in Viton. •MATCO search did not identify BFRs . •MAPTIS search identified flame retardants that did not contain BFRs.
SSME (Space Shuttle Main Engine)	<ul style="list-style-type: none"> •Initial search for BFR-containing materials underway. No materials identified to date. Search is on-going.

IDENTIFICATION OF BFRs IN SSP APPLICATIONS

Elements	BFR Identification Status
RSRM (Reusable Solid Rocket Motor)	<ul style="list-style-type: none"> •Conducted search for BFR-containing materials. •No adverse impacts identified to date.
Logistics	<ul style="list-style-type: none"> •Logistics notified affected Orbiter users that Tyco RNF 100 contained deca-BDE. •Conducted search in “People Soft” data base for materials containing BFRs. Difficult to find these materials because bromides are not listed in MSDSs. •Random searching has identified flame retardants in materials.
Space Suits & EVA (Extravehicular Activity)	<ul style="list-style-type: none"> •Conducted search for BFR-containing materials. •No BFRs identified for Extravehicular Mobility Unit and Life Support Systems. • Assessing impacts to International Latex Corp. (ILC) soft goods. • EVA applications and Space Suits are composed of materials that are inherently flame retardant. •An electronic molding compound utilized on Space Suits does contain Deca-BDEs. The molding compound is utilized per MIL-M-14
KSC Ground Ops, GSE, LSE	<ul style="list-style-type: none"> •Working with Logistics. •Search is ongoing.

LESSONS LEARNED

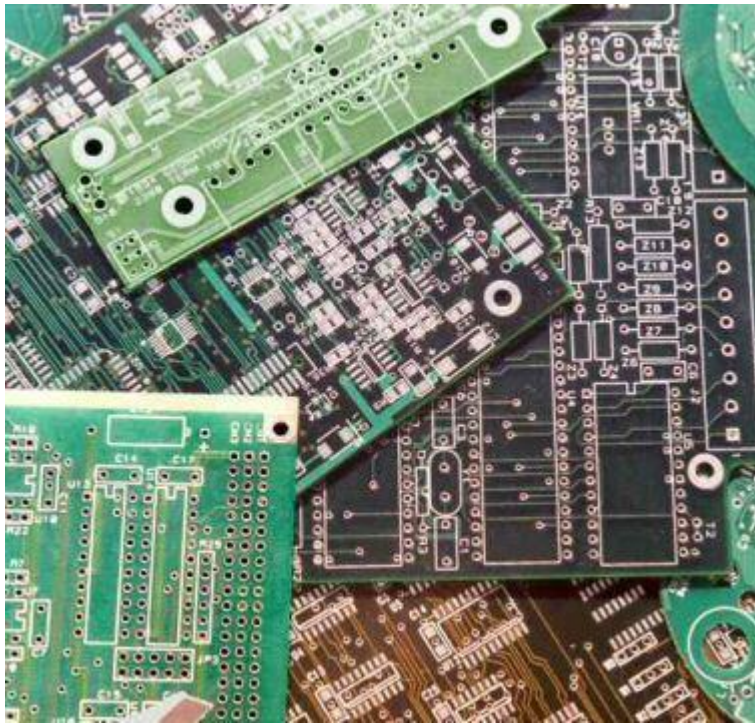
- BFR Searching with Materials Databases
 - ♦ Difficulty in identifying materials containing BFRs when conducting database searches
 - ♦ Bromide contents are not listed in Material Safety Data Sheets (MSDSs). Information is not readily available
- Most Shuttle elements have limited available resources to conduct comprehensive “BFR identification” efforts
- First step for several elements was the identification of “critical” applications where flame retardancy was essential
 - ♦ Materials in Habitable Crew Compartments (Orbiter)
 - ♦ Viton in Thermal Curtains (SRB)
 - ♦ Liquid Oxygen Compatible Environments

LESSONS LEARNED (cont)

- Response to Known BFR Materials Change
 - Shuttle can proactively re-qualify a new material with a different BFR when the vendor readily makes notification that a formulation change has occurred.
- Response to Unknown BFR Materials Change
 - Shuttle placed in a more “reactive” posture. The user may not be aware of the BFR change in the material until the performance of the material is altered, usually during the inspection/receiving process
- Materials Performance
 - Boeing Commercial’s test data of reformulated materials with new BFRs did not reveal a decline in flammability capability.
 - Boeing Commercial's test data did reveal a decrease in tensile strength and adhesion from the reformulated materials.

OTHER AREAS OF CONCERN

Flame retardants are widely used in printed circuit boards



- Tetrabromobisphenol-A (TBBA) is commonly used
- At this time no known restrictions of TBBA
- Many suppliers and manufactures are unaware of brominated parts that they receive

QUESTIONS?